CLAIMS

1. A sol containing modified metal oxide particles which comprise, as nuclei, colloidal particles (A) being stannic oxide particles or composite particles comprising stannic oxide particles and zirconium oxide particles, containing these oxides in a weight ratio of ZrO_2:SnO_2 of from 0:1 to 0.50:1 and having particle sizes of from 4 to 50 nm, and as a coating covering the surface of the nuclei, alkylamine-containing Sb_2O_5 colloidal particles having a M/Sb_2O_5 molar ratio (M represents an amine molecule) of from 0.02 to 4.00, an oligomer thereof or a mixture thereof (B1), in a weight ratio of (B1)/(A) of from 0.01 to 0.50 based on the weights of the metal oxides, and have particle sizes of from 4.5 to 60 nm.

2. The sol according to Claim 1, wherein the colloidal particles (A) are stannic oxide particles.

3. The sol according to Claim 1, wherein the colloidal particles (A) are composite colloidal particles comprising stannic oxide particles and zirconium oxide particles in a weight ratio of ZrO_2:SnO_2 of from 0.05:1 to 0.50:1

4. A sol containing modified metal oxide particles which comprise, as nuclei, colloidal particles (A) being stannic oxide particles or composite particles comprising stannic oxide particles and zirconium oxide particles, containing these oxides in a weight ratio of ZrO_2:SnO_2 of from 0:1 to 0.50:1 and having particle sizes of from 4 to

50 nm, and as a coating covering the surface of the nuclei, composite colloidal particles comprising diantimony pentaoxide and silica having a SiO_2/Sb_2O_5 molar ratio of from 0.55 to 55, an oligomer thereof or a mixture thereof (B2), in a weight ratio of (B2)/(A) of from 0.01 to 0.50 based on the weights of the metal oxides, and have particle sizes of from 4.5 to 60 nm.

5. The sol according to Claim 4, wherein the colloidal particles (A) are stannic oxide particles.

6. The sol according to Claim 4, wherein the colloidal particles (A) are composite colloidal particles comprising stannic oxide particles and zirconium oxide particles in a weight ratio of $ZrO_2:SnO_2$ of from 0.05:1 to 0.50:1

7. A process for producing the sol as defined in Claim 1 or 2, which comprises the following steps (a1), (b1) and (c1):

step (a1): a step of preparing a stannic oxide aqueous sol containing stannic oxide colloidal particles having particle sizes of from 4 to 50 nm at a SnO_2 concentration of from 1 to 50 wt%,

step (b1): a step of mixing the stannic oxide aqueous sol obtained in the above step (a1), with an aqueous medium containing alkylamine-containing Sb_2O_5 colloidal particles having a M/Sb_2O_5 molar ratio (M represents an amine molecule) of from 0.02 to 4.00, an oligomer thereof or a mixture thereof, in a weight ratio

of Sb_2O_5/SnO_2 as calculated as metal oxides of from 0.01 to 0.50, and

step (c1): a step of aging the aqueous medium obtained in step (b1) at a temperature of from 20 to 300°C for from 0.1 to 50 hours.

8. A process for producing the sol as defined in Claim 1 or 3, which comprises the following steps (a2), (b2), (c2) and (d3):

step (a2): a step of mixing a stannic oxide aqueous sol having particle sizes of from 4 to 50 nm and having a SnO_2 concentration of from 0.5 to 50 wt%, with an aqueous solution of an oxyzirconium salt having a concentration of from 0.5 to 50 wt% as calculated as ZrO_2, in a weight ratio of ZrO_2/SnO_2 of from 0.05 to 0.50, and heating the obtained mixed liquid at a temperature of from 60 to 100°C for from 0.1 to 50 hours to prepare a stannic oxide-zirconium oxide composite aqueous sol having particle sizes of from 4 to 50 nm,

step (b2): a step of mixing the stannic oxide-zirconium oxide composite aqueous sol obtained in step (a2), with an aqueous medium containing alkylamine-containing Sb_2O_5 colloidal particles having a M/Sb_2O_5 molar ratio (M represents an amine molecule) of from 0.02 to 4.00, an oligomer thereof or a mixture thereof, in a weight ratio of $Sb_2O_5/(SnO_2+ZrO_2)$ of from 0.01 to 0.50 as calculated as metal oxides,

step (c2): a step of aging the aqueous medium

obtained in step (b2) at a temperature of from 20 to 300°C for from 0.1 to 50 hours, and

step (d2): a step of bringing the modified stannic oxide-zirconium oxide composite aqueous sol obtained in step (c2) into contact with an anion exchanger to remove anions present in the sol.

9. A process for producing the sol as defined in Claim 1 or 2, which comprises the following steps (a3), (b3) and (c3):

step (a3): a step of preparing a stannic oxide aqueous sol subjected to a hydrothermal treatment at a temperature of from 100 to 300°C, and having particle sizes of from 4 to 50 nm and a SnO_2 concentration of from 0.5 to 50 wt%,

step (b3): a step of mixing the stannic oxide aqueous sol obtained in the above step (a3), with an aqueous medium containing alkylamine-containing Sb_2O_5 colloidal particles having a M/Sb_2O_5 molar ratio (M represents an amine molecule) of from 0.02 to 4.00, an oligomer thereof or a mixture thereof, in a weight ratio of Sb_2O_5/SnO_2 as calculated as metal oxides of from 0.01 to 0.50, and

step (c3): a step of aging the aqueous medium obtained in step (b3) at a temperature of from 20 to 300°C for from 0.1 to 50 hours.

10. A process for producing the sol as defined in Claim 1 or 3, which comprises the following steps (a4), (b4),

(c4) and (d4):

step (a4): a step of mixing a stannic oxide aqueous sol subjected to a hydrothermal treatment at a temperature of from 100 to 300°C, and having particle sizes of from 4 to 50 nm and a SnO_2 concentration of from 0.5 to 50 wt%, with an aqueous solution of an oxyzirconium salt having a concentration of from 0.5 to 50 wt% as calculated as ZrO_2, in a weight ratio of ZrO_2/SnO_2 of from 0.05 to 0.50, and heating the obtained mixed liquid at a temperature of from 60 to 100°C for from 0.1 to 50 hours to prepare a stannic oxide-zirconium oxide composite aqueous sol having particle sizes of from 4 to 50 nm,

step (b4): a step of mixing the stannic oxide-zirconium oxide composite aqueous sol obtained in step (a4), with an aqueous medium containing alkylamine-containing Sb_2O_5 colloidal particles having a M/Sb_2O_5 molar ratio (M represents an amine molecule) of from 0.02 to 4.00, an oligomer thereof or a mixture thereof, in a weight ratio of $Sb_2O_5/(SnO_2+ZrO_2)$ of from 0.01 to 0.50 as calculated as metal oxides,

step (c4): a step of aging the aqueous medium obtained in step (b4) at a temperature of from 20 to 300°C for from 0.1 to 50 hours, and

step (d4): a step of bringing the modified stannic oxide-zirconium oxide composite aqueous sol obtained in step (c4) into contact with an anion exchanger to remove

anions present in the sol.

11. A process for producing the sol as defined in Claim 4 or 5, which comprises the following steps (a5), (b5) and (c5):

step (a5): a step of preparing a stannic oxide aqueous sol containing stannic oxide colloidal particles having particle sizes of from 4 to 50 nm at a SnO_2 concentration of from 1 to 50 wt%,

step (b5): a step of mixing the stannic oxide aqueous sol obtained in the above step (a5), with an aqueous medium containing composite colloidal particles of diantimony pentaoxide and silica having a SiO_2/Sb_2O_5 molar ratio of from 0.55 to 55, an oligomer thereof or a mixture thereof, in a weight ratio of $(Sb_2O_5+SiO_2)/(SnO_2)$ as calculated as metal oxides of from 0.01 to 0.50, and

step (c5): a step of aging the aqueous medium obtained in step (b5) at a temperature of from 20 to 300°C for from 0.1 to 50 hours.

12. A process for producing the sol as defined in Claim 4 or 6, which comprises the following steps (a6), (b6), (c6) and (d6):

step (a6): a step of mixing a stannic oxide aqueous sol having particle sizes of from 4 to 50 nm and a SnO_2 concentration of from 0.5 to 50 wt%, with an aqueous solution of an oxyzirconium salt having a concentration of from 0.5 to 50 wt% as calculated as ZrO_2, in a weight ratio of ZrO_2/SnO_2 of from 0.05 to 0.50, and heating the

obtained mixed liquid at a temperature of from 60 to 100°C for from 0.1 to 50 hours to prepare a stannic oxide-zirconium oxide composite aqueous sol having particle sizes of from 4 to 50 nm,

step (b6): a step of mixing the stannic oxide-zirconium oxide composite aqueous sol obtained in step (a6), with an aqueous medium containing composite colloidal particles of diantimony pentaoxide and silica having a SiO_2/Sb_2O_5 molar ratio of from 0.55 to 55, an oligomer thereof or a mixture thereof, in a weight ratio of $(Sb_2O_5+ SiO_2)/(SnO_2+ZrO_2)$ as calculated as metal oxides of from 0.01 to 0.50,

step (c6): a step of aging the aqueous medium obtained in step (b6) at a temperature of from 20 to 300°C for from 0.1 to 50 hours, and

step (d6): a step of bringing the modified stannic oxide-zirconium oxide composite aqueous sol obtained in step (c6) into contact with an anion exchanger to remove anions present in the sol.

13. A process for producing the sol as defined in Claim 4 or 5, which comprises the following steps (a7), (b7) and (c7):

step (a7): a step of preparing a stannic oxide aqueous sol subjected to a hydrothermal treatment at a temperature of from 100 to 300°C, and having particle sizes of from 4 to 50 nm and a SnO_2 concentration of from 0.5 to 50 wt%,

step (b7): a step of mixing the stannic oxide aqueous sol obtained in the above step (a7), with an aqueous medium containing composite colloidal particles of diantimony pentaoxide and silica having a SiO_2/Sb_2O_5 molar ratio of from 0.55 to 55, an oligomer thereof or a mixture thereof, in a weight ratio of $(Sb_2O_5+SiO_2)/(SnO_2)$ as calculated as metal oxides of from 0.01 to 0.50, and

step (c7): a step of aging the aqueous medium obtained in step (b7) at a temperature of from 20 to 300°C for from 0.1 to 50 hours.

14. A process for producing the sol as defined in Claim 4 or 6, which comprises the following steps (a8), (b8), (c8) and (d8):

step (a8): a step of mixing a stannic oxide aqueous sol subjected to a hydrothermal treatment at a temperature of from 100 to 300°C, and having particle sizes of from 4 to 50 nm and a SnO_2 concentration of from 0.5 to 50 wt%, with an aqueous solution of an oxyzirconium salt having a concentration of from 0.5 to 50 wt% as calculated as ZrO_2, in a weight ratio of ZrO_2/SnO_2 of from 0.05 to 0.50, and heating the obtained mixed liquid at a temperature of from 60 to 100°C for from 0.1 to 50 hours to prepare a stannic oxide-zirconium oxide composite aqueous sol having particle sizes of from 4 to 50 nm,

step (b8): a step of mixing the stannic oxide-zirconium oxide composite aqueous sol obtained in step

(a8), with an aqueous medium containing composite colloidal particles of diantimony pentaoxide and silica having a SiO_2/Sb_2O_5 molar ratio of from 0.55 to 55, an oligomer thereof or a mixture thereof, in a weight ratio of $(Sb_2O_5+SiO_2)/(SnO_2+ZrO_2)$ as calculated as metal oxides of from 0.01 to 0.50,

step (c8): a step of aging the aqueous medium obtained in step (b8) at a temperature of from 20 to 300°C for from 0.1 to 50 hours, and

step (d8): a step of bringing the modified stannic oxide-zirconium oxide composite aqueous sol obtained in step (c8) into contact with an anion exchanger to remove anions present in the sol.

15. A coating composition containing the following components (S) and (T1):

component (S): at least one silicon-containing substance selected from the group consisting of organic silicon compounds of the formulae (I) and (II), and hydrolysates thereof:

$$(R^1)_a(R^3)_bSi(OR^2)_{4-(a+b)} \qquad (I)$$

wherein each of R^1 and R^3 is an alkyl group, an aryl group, a halogenated alkyl group, a halogenated aryl group, an alkenyl group, or an organic group having an epoxy group, an acryloyl group, a methacryloyl group, a mercapto group, an amino group or a cyano group, which is bonded to the silicon atom by a Si-C bond, R^2 is a C_{1-8} alkyl group, an alkoxyalkyl group or an acyl group, and

each of a and b is an integer of 0, 1 or 2, provided that a+b is an integer of 0, 1 or 2,

$$[(R^4)_cSi(OX)_{3-c}]_2Y \qquad (II)$$

wherein R^4 is a C_{1-5} alkyl group, X is a C_{1-4} alkyl group or an acyl group, Y is a methylene group or a C_{2-20} alkylene group, and c is an integer of 0 or 1;

component (T1): modified metal oxide particles, which comprise, as nuclei, colloidal particles (A) being stannic oxide particles or composite particles comprising stannic oxide particles and zirconium oxide particles, containing these oxides in a weight ratio of ZrO_2:SnO_2 of from 0:1 to 0.50:1 and having particle sizes of from 4 to 50 nm, and as a coating covering the surface of the nuclei, alkylamine-containing Sb_2O_5 colloidal particles having a M/Sb_2O_5 molar ratio (M represents an amine molecule) of from 0.02 to 4.00, an oligomer thereof or a mixture thereof (B1), in a weight ratio of (B1)/(A) of from 0.01 to 0.50 based on the weights of the metal oxides, and have particle sizes of from 4.5 to 60 nm.

16. The coating composition according to Claim 15, wherein the colloidal particles (A) are stannic oxide particles.

17. The coating composition according to Claim 15, wherein the colloidal particles (A) are composite colloidal particles comprising stannic oxide particles and zirconium oxide particles in a weight ratio of ZrO_2:SnO_2 of from 0.05:1 to 0.50:1

18. The coating composition according to any one of Claims 15 to 17, wherein the coating (B1) in the component (T1) further contains an alkylamine-containing silica.

19. A coating composition containing the following components (S) and (T2):

component (S): at least one silicon-containing substance selected from the group consisting of organic silicon compounds of the formulae (I) and (II), and hydrolysates thereof:

$$(R^1)_a(R^3)_bSi(OR^2)_{4-(a+b)} \qquad (I)$$

wherein each of R^1 and R^3 is an alkyl group, an aryl group, a halogenated alkyl group, a halogenated aryl group, an alkenyl group, or an organic group having an epoxy group, an acryloyl group, a methacryloyl group, a mercapto group, an amino group or a cyano group, which is bonded to the silicon atom by a Si-C bond, R^2 is a C_{1-8} alkyl group, an alkoxyalkyl group or an acyl group, and each of a and b is an integer of 0, 1 or 2, provided that a+b is an integer of 0, 1 or 2,

$$[(R^4)_cSi(OX)_{3-c}]_2Y \qquad (II)$$

wherein R^4 is a C_{1-5} alkyl group, X is a C_{1-4} alkyl group or an acyl group, Y is a methylene group or a C_{2-20} alkylene group, and c is an integer of 0 or 1;

component (T2): modified metal oxide particles, which comprise, as nuclei, colloidal particles (A) being stannic oxide particles or composite particles comprising

stannic oxide particles and zirconium oxide particles, containing these oxides in a weight ratio of ZrO_2:SnO_2 of from 0:1 to 0.50:1 and having particle sizes of from 4 to 50 nm, and as a coating covering the surface of the nuclei, composite colloidal particles comprising diantimony pentaoxide and silica having a SiO_2/Sb_2O_5 molar ratio of from 0.55 to 55, an oligomer thereof or a mixture thereof (B2), in a weight ratio of (B2)/(A) of from 0.01 to 0.50 based on the weights of metal oxides, and have particle sizes of from 4.5 to 60 nm.

20. The coating composition according to Claim 19, wherein the colloidal particles (A) are stannic oxide particles.

21. The coating composition according to Claim 19, wherein the colloidal particles (A) are composite colloidal particles comprising stannic oxide particles and zirconium oxide particles in a weight ratio of ZrO_2:SnO_2 of from 0.05:1 to 0.50:1.

22. The coating composition according to any one of Claims 19 to 21, wherein the coating (B2) in the component (T1) further contains an alkylamine-containing silica.

23. The coating composition according to any one of Claims 15 to 22, wherein the component (A) is at least one silicon-containing substance selected from the group consisting of the organic silicon compound of the formula (I) and a hydrolysate thereof.

24. The coating composition according to any one of claims 15 to 23, which contains at least one curing catalyst selected from the group consisting of a metal salt, a metal alkoxide and a metal chelate compound.

25. An optical element comprising an optical substrate and a cured film formed from the coating composition as defined in any one of Claims 15 to 24 on the surface of the optical substrate.

26. The optical element according to Claim 25, which further has an antireflection film formed on its surface.